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ARTIFICIAL INTELLIGENCE IN DERMATOLOGY: OPPORTUNITIES, LIMITATIONS, ETHICAL CHALLENGES AND HEALTH EQUITY – A NARRATIVE REVIEW

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ABSTRACT

Background: Artificial intelligence (AI) has become a promising tool in dermatology that could improve diagnostic accuracy, optimize clinical workflows, and expand access to dermatological care. Recent advances in machine learning and deep learning have enabled the development of highly accurate image-analysis systems, particularly for the diagnosis of skin lesions. However, the implementation of AI in clinical practice is accompanied by important ethical, legal, and equity-related challenges.
Objective: This narrative review aims to summarize the current evidence regarding the applications of artificial intelligence in dermatology, with particular emphasis on its potential to improve healthcare accessibility, support teledermatology, and promote health equity while addressing existing limitations and ethical concerns.
Methods: A narrative review of the literature was conducted using PubMed, PubMed Central, and Google Scholar. Peer-reviewed articles published in English between 2017 and 2025 were included. The literature was selected using keywords related to artificial intelligence, dermatology, skin cancer, teledermatology, and health equity.
Results: The reviewed literature demonstrates that AI has achieved high diagnostic performance in the recognition of various skin diseases, particularly malignant skin lesions, and may significantly improve access to dermatological services through teledermatology and decision-support systems. Nevertheless, challenges including algorithmic bias, limited representation of diverse skin phototypes in training datasets, data privacy concerns, and insufficient regulatory frameworks remain substantial barriers to widespread implementation.
Conclusions: Artificial intelligence has the potential to transform dermatological care by enhancing diagnostic efficiency and improving healthcare accessibility. However, its successful integration into clinical practice requires diverse and representative datasets, robust ethical and legal standards, and continued human oversight to ensure safe, equitable, and patient-centered healthcare.

KEYWORDS

Artificial Intelligence, Dermatology, Health Equity, Skin Cancer, Teledermatology, Deep Learning

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1. Introduction

Artificial intelligence (AI) is defined by the Association for the Advancement of Artificial Intelligence as “the scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines” [25]. It refers to the development of computer systems able to perform tasks that normally require human cognitive functions, such as visual perception, speech recognition, learning from data, reasoning, pattern recognition, and solving complex problems. In recent years, artificial intelligence (AI) has become one of the most transformative technologies used in modern healthcare, improving disease diagnosis and patient treatment [4,5].

Nowadays, rapid advances can be observed in machine learning (ML) and deep learning (DL) algorithms. Machine learning (ML) refers to algorithms and statistical models that learn from training data, recognise and infer patterns, and do not require explicit instructions from a human operator. An artificial neural network (ANN), a subset of machine learning, is classified as deep learning (DL) when it has many interconnected layers. A convolutional neural network (CNN), a specialised type of deep learning algorithm, applies filters to images to identify specific features. CNNs are designed to process and analyse grid-structured data, such as images and videos. Their ability to analyse large amounts of medical data with high accuracy and efficiency makes them a realistic prospect in dermatology [1,4,12].

Various types of AI are used by healthcare providers and medical companies. Among medical specialties, dermatology has emerged as one of the most promising fields for implementing AI tools because of its strong reliance on visual assessment and image-based diagnostics. Since the 2000s, AI has had an increasing presence in clinical settings, changing how skin conditions are identified, treated, and managed [4,5,9,25].

Dermatology is a branch of medicine concerned with conditions affecting the skin, hair, nails, and mucous membranes. It is a specific field of medicine in which the macroscopic, dermoscopic, and dermatopathological appearances of lesions play a key role in diagnosis. A large number of databases contain images representing numerous different lesions. Such databases create an ideal environment for AI algorithms to learn and provide image-based diagnoses. Currently, dermatology is one of the most promising fields for the implementation of AI in medicine [4,5,25].

Non-melanoma skin cancer is the most common human malignancy worldwide, and melanoma is one of the deadliest forms of cancer [1,4]. There are 5.4 million new cases of skin cancer in the United States every year. One in five Americans will be diagnosed with a cutaneous malignancy in their lifetime [1]. Mortality is high, particularly at advanced stages. The estimated 5-year survival rate for melanoma drops from over 99% when detected at its earliest stage to about 14% when detected at an advanced stage. For these reasons, early detection is very important and should be a priority in dermatological care [1,4].

To diagnose skin lesions, including skin cancer, dermatologists perform visual inspection with the naked eye and, when appropriate, dermoscopic analysis. Dermatoscopy is a non-invasive imaging technique that uses a dermatoscope—a specialised magnifying instrument that helps visualise lesion details [1,4,24].

After dermoscopic examination, suspicious and potentially malignant lesions are biopsied and examined histopathologically. Although diagnostic criteria are established, decisions rely on visual assessment and the dermatologist's expertise, which creates a risk of human error [1]. However, dermatology is not limited to melanoma, and AI can support the assessment of a range of diseases. Artificial intelligence-based tools have also been developed to evaluate the severity of acne and psoriasis and to diagnose onychomycosis, vitiligo, and other conditions [6,22].

In several countries, access to dermatological care among the general population is limited. It is estimated that 3 billion people worldwide have inadequate access to medical care for skin diseases. Many regions experience a shortage of dermatologists, long waiting times for specialist consultations, and disparities in healthcare availability between urban and rural populations. Many adult patients have never undergone a total body skin examination (TBSE) by an expert dermatologist [4,13,16]. These challenges create an opportunity for technological innovations to support healthcare professionals and improve access to dermatological services. Properly developed and implemented AI systems may contribute to reducing disparities by improving access to specialist consultations, supporting teledermatology, and enabling earlier diagnosis in resource-limited settings.

However, without appropriate regulation and adequate data collection strategies, AI may reinforce pre-existing inequalities. It was not until 2024 that the FDA approved the first AI-powered skin cancer diagnostic tool (DermaSensor™). In Europe, several commercial skin cancer detection applications have the CE mark [13].

2. Methods

This study was designed as a narrative review of the literature. The aim of the study is to summarize current evidence regarding the use of artificial intelligence in dermatology, with particular emphasis on its potential to improve access to dermatological care, existing limitations, ethical challenges, and implications for health equity. Furthermore, this review discusses future directions for the responsible implementation of AI technologies to ensure equitable and safe dermatological care.

To achieve this, the authors conducted a review of relevant and current articles from the PubMed and Google Scholar databases. The search strategy included combinations of keywords such as "artificial intelligence", "dermatology", "health equity", "skin cancer", "teledermatology", and "deep learning". To improve the accuracy of the results, the Boolean operators "AND" and "OR" were used.

Priority was given to recent studies, review articles, meta-analyses and clinical investigations. Articles published between 2015 and 2026 in English were included.

The analysis excluded non-peer-reviewed publications, case studies, and conference abstracts without full text. Studies focusing on the use of artificial intelligence in medical specialties other than dermatology, as well as publications not available in English, were also excluded.

The selection process proceeded in several stages. First, titles and abstracts were screened for thematic relevance, and then the full texts of the selected studies were analysed. The collected material was grouped according to thematic categories.

The selected literature was reviewed and synthesized narratively according to major thematic areas.

Although no risk-of-bias tool was used, the methodological quality of the included studies was critically analyzed by the authors.

Due to the nature of this narrative review, formal systematic procedures, such as PRISMA, were not used, which is a potential limitation of the study.

3. Artificial intelligence in dermatology

Artificial intelligence (AI), machine learning (ML), and convolutional neural networks (CNNs) are becoming realistic prospects in dermatology. The evolution of AI includes classical AI, machine learning, and deep learning, with deep learning currently representing the most advanced approach. AI-assisted diagnosis can minimise diagnostic errors and help clinicians choose the most appropriate treatment. This human–AI collaboration can lead to the best treatment outcomes for patients [4].

3.1 Machine learning

Machine learning (ML) is a branch of artificial intelligence (AI). Algorithms learn to perform specific tasks from data rather than through explicitly programmed instructions. AI has evolved from classical artificial intelligence to machine learning and then to deep learning. As a branch of artificial intelligence, machine learning enables systems to learn automatically without explicit programming instructions. This process may be unsupervised, in which a machine analyses input data without predefined answers; semi-supervised, in which part of the data is labelled and part is unlabelled; or supervised, in which models are trained on labelled examples. Supervised learning minimises the differences between model predictions and expert-assigned labels and is therefore the most widely used approach in clinical medicine and dermatology because diagnostic image datasets are typically annotated by dermatologists. In practice, this means that a model is trained using examples such as dermoscopic or clinical images with the correct diagnosis. The learned patterns are then applied to new, unseen cases [5,12,25].

3.2 Deep learning

Deep learning represents a further stage in the evolution of artificial intelligence. It is a subset of machine learning that uses artificial neural networks (ANNs) inspired by biological neural networks. These networks can contain numerous interconnected layers, each performing mathematical operations. Increasing the number of layers enables the network to learn more complex representations of data. Each layer within the neural network can be trained to recognise different features specific to the dataset. Deep neural networks (DNNs) are capable of learning hierarchical feature representations directly from raw images. Their training requires repeated adjustment of network parameters and substantial computational resources, often involving graphics processing units [4,12,25].

3.3 Convolutional Neural Networks (CNN)

Convolutional neural networks (CNNs) are a specific type of deep neural network developed primarily for the analysis and classification of image data. They consist of multiple computational layers that progressively transform input data and extract features of increasing complexity. In dermatology, CNNs are particularly relevant because diagnosis often depends on the recognition of visual patterns. CNNs are trained using clinical, dermoscopic, and histopathological images. An important advantage is their ability to learn directly from raw image pixels without requiring the manual extraction of predefined visual features. In this way, CNNs can create complex internal representations. The development of CNNs has enabled automated systems to analyse skin images and assign them to predefined diagnostic categories [8,12,25].

3.4 Current applications

Artificial intelligence, particularly systems based on convolutional neural networks, is currently applied in dermatology primarily to analyse clinical, dermoscopic, and histopathological images. These systems can perform binary classification, such as distinguishing malignant from benign lesions, as well as multiclass classification involving numerous skin diseases. More advanced systems analyse images of skin lesions together with medical history data [3,5,9].

Melanoma recognition is one of the best-studied applications of AI in dermatology. CNN-based models have been developed to distinguish melanoma from benign melanocytic nevi. The application of AI to melanoma has expanded beyond simple melanoma-versus-nevus classification. Currently, AI is capable of multiclass diagnosis, differentiation between melanoma subtypes, and assessment of lesions in less common anatomical locations. It has also been investigated for differentiating early melanomas from atypical nevi. CNNs may support melanoma recognition not only at the clinical and dermoscopic levels but also during microscopic tissue assessment. The ability to differentiate combined nevi from melanomas can support crucial decisions concerning whether a suspicious lesion should be biopsied or monitored. The diagnostic performance of AI was comparable to that of clinicians and, at selected thresholds, showed even greater diagnostic accuracy. Promising overall performance does not mean that an algorithm can reliably recognise all clinical variants of melanoma. The diagnostic accuracy of CNNs differs between melanoma subtypes and lesion locations [5,8,25].

Applications for squamous cell carcinoma (SCC) overlap with those developed for basal cell carcinoma (BCC). However, performance appears less consistent for SCC than for BCC. These applications mainly support differential diagnosis and assist clinicians in teledermatology and primary care. These systems can potentially help non-specialists identify patients requiring dermatological assessment [1,5,7,9].

Benign lesions play an essential role in dermatological AI because they serve both as comparators for malignant tumors and as independent diagnostic classes. Their accurate classification is clinically important because false-positive malignant predictions may lead to unnecessary biopsies, excisions, and patient anxiety. Nevertheless, benign lesions remain underrepresented in many datasets, which may reduce performance in real clinical populations [5,7,22].

In acne vulgaris and vitiligo, AI is applied to differential diagnosis, objective monitoring, severity grading, and treatment support. Smartphone-based applications for the assessment of acne vulgaris can detect lesions, calculate severity, and incorporate information such as age, sex, and skin type. However, variation between grading systems, lighting, camera quality, distance, and image angle limits the reliability of these systems. Standardised image acquisition and external clinical validation are therefore required before these tools can reliably guide routine monitoring or treatment [22].

Overall, current applications range from cancer recognition and differential diagnosis to severity assessment, treatment monitoring, and mobile decision support. Their clinical value depends on representative datasets, reliable reference diagnoses, standardised image acquisition, external validation, and continued clinician supervision. AI may be most useful as a decision-support system for clinicians. It should not be used as an autonomous replacement for professional assessment [5,9,22].

4. AI and access to dermatological care

Access to dermatological services remains a significant challenge worldwide. In some geographical regions, the doctor-to-patient ratio is low, and many adults have never undergone a total body skin examination (TBSE) by an expert dermatologist [4,16]. The insufficient number of dermatologists leads to long waiting times and delays in diagnosis and treatment, particularly in rural and underserved regions [16,22]. This also means that many cases are assessed by general practitioners, who may have lower diagnostic accuracy [11]. Integrating AI tools with teledermatology could help address these challenges. AI systems may help provide access to specialist consultations.

Telemedicine visits based on video or phone calls became widespread during the COVID-19 pandemic and are now a convenient way to conduct medical consultations [10,26]. Teledermatology enables remote consultation through video transmission or the assessment of images of skin lesions taken by patients and sent to a physician. The addition of AI algorithms further supports lesion classification, the prioritisation of urgent referrals, and healthcare professionals in clinical decision-making. AI tools could enable initial self-assessment at home without an in-person or remote consultation, which could become increasingly important for the efficient allocation of healthcare resources [6,16,17].

Several studies have demonstrated that AI can improve the efficiency of patient triage. Properly trained applications can identify lesions by comparing them with a database of possible skin conditions and classify them into various risk categories [5,26]. Automated systems could reduce unnecessary specialist consultations for benign conditions. Such approaches may decrease healthcare costs and help address shortages of specialists [9]. AI could also provide a “second opinion” to support dermatologists or prompt them to change their clinical diagnosis [5,26].

AI-assisted teledermatology is especially needed in low-resource regions, where access to dermatological expertise is limited [16]. Smartphone-based applications and cloud-based diagnostic platforms allow general practitioners to obtain rapid specialist support, facilitating earlier diagnosis and improved treatment outcomes [21]. In primary care, AI-based algorithms can help improve diagnosis by non-dermatologists in cases where patients might otherwise be referred to specialists [11].

There are also tools that patients can use themselves, such as smartphone applications that allow image-based self-assessment of skin lesions [22].

The educational role of these tools should not be overlooked. Many smartphone apps provide education about skin lesions and melanoma prevention through lectures, presentations, and information on preventing exposure to UV radiation; some also facilitate remote consultation with specialists [5].

Despite these advantages, AI should not be considered a replacement for dermatologists. Most authors emphasise that AI functions best as a decision-support tool, complementing rather than replacing physical examination. Diagnosis cannot be based solely on images. Clinical examination, the patient's medical history, and assessment of skin lesions are necessary for accurate diagnosis and treatment, particularly in atypical or complex cases [5,12].

5. Health equity challenges

In dermatology, a specialty focused on the skin, skin color is important for correct diagnosis. This is partly because some skin tones may be associated with a greater risk of certain dermatological disorders; for example, darker skin tones are associated with an increased risk of hyperpigmentation and keloid formation [15]. Dermatological diseases may also manifest differently depending on skin tone. People of color have historically experienced greater difficulty in receiving correct diagnoses and treatment because of a lack of research focused on populations with skin of color [15]. The same risk applies to the use of AI in dermatology.

Artificial intelligence used in dermatology could improve the diagnostic process and enhance access to professional care. Without inclusive development, however, it could instead exacerbate healthcare disparities [14]. To avoid this, all patient populations should have equal access to the benefits of these technologies.

One of the biggest challenges is algorithmic bias resulting from non-representative training datasets. Many databases are small and predominantly contain images of patients with fair skin phototypes [7,9]. AI is only as good as the data from which it learns. Consequently, these algorithms often demonstrate reduced diagnostic performance when evaluating skin conditions in patients with darker skin tones [13,16]. Studies have shown decreases in diagnostic accuracy when AI models are tested on datasets containing images of darker skin tones, highlighting the need for more representative training data [13,15,16]. It is important to recognise that skin types cannot be reduced to only "lighter" and "darker" categories. Diversity in dermatological training datasets requires the inclusion of patients from all ethnic groups and across the full spectrum of skin tones.

Furthermore, dataset bias contributes to unequal healthcare outcomes by generating incorrect diagnoses for patients from underrepresented populations. The lack of different skin types in current datasets has been identified as a potential source of widening healthcare inequalities [9,13]. Interestingly, similar disparities have also been observed among human clinicians, underlining that both artificial intelligence and medical education require greater representation of skin diseases across different skin phototypes [13,14].

The digital divide is also a potential challenge. Effective use of AI-supported teledermatology requires access to smartphones or tablets and reliable internet connections. Smartphones available on the market differ significantly in terms of operating parameters and camera resolution, which may affect the performance of dermatological applications [2,9,13]. Unfortunately, technology could also leave marginalised groups behind. Individuals with lower socioeconomic status or limited digital literacy could be excluded from the benefits of AI-assisted healthcare [14].

Future directions are clear but not easy to implement. AI should support equitable healthcare delivery by improving diagnostic efficiency without replacing physicians. Training databases require more inclusive data, including images of skin lesions across a wide range of skin tones. Technological innovation could then benefit all patient groups regardless of ethnicity, socioeconomic status, or geographic location.

6. Ethical and legal considerations

AI is accompanied by ethical and legal concerns, which complicate the implementation of artificial intelligence in dermatology. AI systems have the potential to redefine dermatological care. However, success depends on clarity and acceptance by both physicians and patients, which requires an understanding of the potential benefits and harms of using AI [6,17]. To achieve this, appropriate regulations must be established.

Most researchers highlight that ethical regulations should be based on fairness, inclusivity, diversity, transparency, conflicts of interest, accountability, security, data privacy, and informed consent [17,18,19]. Medical AI should be guided by beneficence and non-maleficence.

Data privacy is important because medical histories and dermatological images are sensitive data and must not be used or processed for inappropriate purposes. AI systems in dermatology make diagnoses based on photographs of patients' skin lesions as well as medical and demographic information. There is a risk that these data may be transferred to commercial institutions and used improperly. For clarity, administrators should explain what information is collected, for how long it is stored, why it is required, who may access it, and how consent can be withdrawn. Minimisation, anonymisation, and encryption of collected data are recommended. These actions reduce the risk, but robust cybersecurity systems and transparent rules governing the secondary use of data are essential [18,19].

Because AI systems operate on sensitive data, explicit patient consent must be obtained for the use of photographs and medical histories for two purposes: providing appropriate care and developing algorithms [5,27]. Consent is informed when patients are fully informed from the outset about how their data will be collected, used, and protected and freely agree to such use. Consent for photography cannot automatically be interpreted as permission for future algorithm development or secondary use. Medical data are a valuable resource for healthcare; therefore, patients must know how AI will use their information and must consent to this use [27].

Healthcare professionals who use AI systems and receive only their outputs cannot follow the entire decision-making process. For this reason, some perceive deep learning systems as a "black box" [5,20]. To make AI less opaque and more trustworthy, it must be transparent. Transparency does not require every user to fully understand a mathematical model. Instead, information about the intended use, training population, known limitations, and confidence level should be clearly communicated and accessible for review [23]. To make an appropriate diagnosis with AI tools, dermatologists need clear explanations of the system's decisions and confidence in the tool. Transparency helps clinicians make the best possible decisions for their patients [5].

Like human doctors, AI algorithms can also make mistakes. Establishing responsibility for incorrect diagnoses generated by AI is a complex problem. Responsibility may lie with the software developer, device manufacturer, database provider, physician, medical facility, or another party [5]. There is a risk that a defective AI model may repeatedly produce incorrect diagnoses for many patients, potentially causing more widespread harm than a single human error. Human supervision is required to prevent automation bias and identify potential errors. Specific regulations and clear rules are needed regarding responsibility and dermatologists' control over diagnosis. This also emphasises the importance of transparency.

7. Future directions

AI applications in dermatology are advancing rapidly but also face challenges that constitute important areas for future development.

Future research should focus on measurable clinical utility. Conventional metrics such as sensitivity, specificity, and the area under the receiver operating characteristic curve do not necessarily show that an algorithm improves patient outcomes. Prospective, multicentre studies conducted within routine clinical pathways are essential. Researchers should pay greater attention to AI's ability to reduce the rates of missed malignancies, unnecessary biopsies, diagnostic delays, and inappropriate referrals. Using AI technologies as decision-support systems for clinicians is currently the most promising direction [3,19].

External validation and out-of-distribution testing should become standard components of dermatological AI research. Algorithms perform well on images obtained from sources similar to their training data, but their accuracy decreases when they are applied to different hospitals, populations, devices, or clinical environments. The performance of AI on photographs affected by poor lighting, compression, blur, or other imperfections should be examined. Study reports should clearly describe the training, validation, and test populations, dataset overlap, diagnostic reference standards, and the use of external validation. Malignant lesions should be confirmed histopathologically. The limitations of diagnoses based solely on visual expertise should be acknowledged [1,3].

Improving the diversity and representativeness of training data is fundamental. In the future, datasets should include a wider range of skin tones, ages, anatomical locations, disease stages, and unusual presentations. Future evaluations should include images from multiple countries and healthcare centers and images acquired using a variety of cameras and dermatoscopes [13,14,15]. Another option for maximising reliability is the standardisation of equipment and imaging techniques used in AI-assisted diagnosis. Future models should also include coexisting diseases, pediatric patients, rare disorders, and a wider spectrum of inflammatory, infectious, pigmentary, hair, and nail conditions rather than focusing mainly on melanoma-versus-nevus classification [4,11,22].

Successful implementation of AI systems in dermatology requires transparency and clear regulation. Regulatory standards should address validation, data quality, cybersecurity, explainability, model updates, and responsibility for harmful outcomes [5,17,18]. Fundamental measures include the minimisation, anonymisation, and encryption of collected data. A privacy policy and the patient's informed consent are also required [27].

8. Conclusions

Artificial intelligence has significant potential to improve access to dermatological care. However, AI should be a supportive tool, not a replacement for physicians.

Algorithmic bias and insufficient representation of diverse skin phototype remain major challenges. Future development should prioritize equitable datasets, inclusivity, transparency, and human-centered implementation.

Additional challenges include ethical regulations, data privacy, patient consent, transparency of algorithmic decision-making and responsibility for diagnostic errors.

Standardization of equipment and imaging techniques used for imaging in everyday clinical work may improve accuracy and reliability of AI decisions-supporting systems for clinicians. For now, using AI technologies as a decision-supporting system for clinicians is the most promising direction.

The amount of external validations and out-of-distribution testing should be increased. AI should be challenged with images from different environments, devices, and with different quality in order to become a more reliable source of diagnostic information.

With responsible implementation, artificial intelligence may contribute to more effective, accessible, and equitable dermatological care.

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